B737NG Alerting Issues – Traffic conflict

1. Initiating Condition: Traffic conflict in ATC radar environment (operational error or pilot deviation)

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	TCAS RA vertical guidance on PFD/EADI: red avoid lines on PFD attitude and/or vertical speed areas	Proximity detected by TCAS at RA threshold			RA automatically suppressed by higher order warnings (e.g., stall, wind shear, terrain) and in certain altitude regimes; pilots must manually suppress RA in certain conditions, e.g., closely spaced parallel approaches and engine failures	TCAS removes visual alerts/cues and annunciates clear of conflict (aural)
	TCAS red TRAFFIC message on ND	Proximity detected by TCAS at RA threshold			RA automatically suppressed by higher order warnings (e.g., stall, wind shear, terrain) and in certain altitude regimes; pilots must manually suppress RA in certain conditions, e.g., closely spaced parallel approaches and engine failures	TCAS removes visual alerts/cues and annunciates clear of conflict (aural)
Aural Alerts	ATC Traffic Alert	Proximity detected by ATC radar/ conflict alert at system's threshold	Pilot has to hear, comprehend, and react to verbally transmitted information from ATC			
	TCAS RA aural warning	Proximity detected by TCAS at RA threshold			RA automatically suppressed by higher order warnings (e.g., stall, wind shear, terrain) and in certain altitude regimes; pilots must manually suppress RA in certain conditions, e.g., closely spaced parallel approaches and engine failures	TCAS removes visual alerts/cues and annunciates clear of conflict (aural)
Tactile Alerts	None					
Visual Cues	TCAS display of traffic proximity on ND (filled red square for RA)	Proximity detected by TCAS at RA threshold	Potential confusion in RA display on EHSI/ND between up/down arrow symbology and +/- symbology		RA automatically suppressed by higher order warnings (e.g., stall, wind shear, terrain) and in certain altitude regimes; pilots must manually suppress RA in certain conditions, e.g., closely spaced parallel approaches and engine failures	TCAS removes visual alerts/cues and annunciates clear of conflict (aural)

B737NG Alerting Issues – Traffic conflict

1. Initiating Condition: Traffic conflict in ATC radar environment (operational error or pilot deviation) – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Cues	Visual contact with traffic	Human visual search, detection, selective attention, personal subjective evaluation	Pilot evaluation of detected visual traffic can be misleading as to projected proximity and/or possibly mistaking one threat aircraft for another		Visual traffic cues can be masked by weather and aircraft structure	
Aural Cues	None					
Tactile/ Somatic Cues	None					

Expected Pilot Response(s)

- Maneuver vertically in response to TCAS RA directives.
- Prioritize TCAS RA information over ATC and visual detection information.
- Maneuver vertically and/or laterally as instructed by ATC.
- Maneuver vertically and/or laterally as prompted by visual closure rate and direction of movement.
- The system is designed with the expectation that the pilot will respond within 5 seconds.
- In the case of a corrective RA (e.g. a reversal) the system is designed to expect a pilot response within 2.5 seconds
- Pilot is expected to maintain the requested climb/descent until the aural "clear of conflict" is heard
- Report TCAS RA to ATC as soon as possible
- Caution for endangering passengers with unnecessarily abrupt compliance maneuvers

B737NG Alerting Issues – Traffic conflict

1. Initiating Condition: Traffic conflict in ATC radar environment (operational error or pilot deviation) – Cont.

Possible sources of confusion with regard to pilot response(s)

- RA directives may conflict with ATC directives, so pilots need to react in accordance with TCAS RA despite receiving conflicting instructions.
- RA directives may conflict with ATC directives, so pilots need to ignore habituated response to ATC.
- RA directives may conflict with visual detection of traffic conflict, so pilots need to react in accordance with TCAS RA despite receiving conflicting visual information.
- There are 12 different aural commands that can be issued. Many of which are rarely heard and have been confused by pilots as to the expected response
- Pilot focusing intently on the VSI and climb/descent requirements that thrust/airspeed is not effectively managed
- Failure to disconnect the AP when starting to comply with TCAS RA
- Lateral evasive maneuvers are not to be accomplished utilizing display on MFD. Only when in visual contact should lateral changes be accomplished.
- TCAS does not respond to aircraft that are not equipped with a transponder

How does pilot know condition is resolved/recovered?

- TCAS "Clear of conflict" aural.

B737NG Alerting Issues – Traffic conflict

2. Initiating Condition: Traffic conflict in Next-Gen ATM environment (ground-based sequencing/metering error or datacom error)

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	ADS-In RA vertical guidance on PFD/EADI	Proximity detected by ATM system and/or CDTI (TCAS-like) processing at RA threshold		Future alert/cue designs may differ from current TCAS designs.		
Aural Alerts	ATM Traffic Alert	Proximity detected by ATM system at RA threshold				
	ADS-In RA aural warning	Proximity detected by ATM system and/or CDTI (TCAS-like) processing at RA threshold				
Tactile Alerts	None	None				
Visual Cues	ADS CDTI with conflict display on EHSI/ND	CDTI conflict display system threshold				
	Visual contact with traffic	Human visual search, detection, selective attention, personal subjective evaluation (N.B., closer traffic tolerances under NextGen)	Pilot evaluation of detected visual traffic can be misleading as to projected proximity and/or possibly mistaking one threat aircraft for another		Visual traffic cues can be masked by weather and aircraft structure	
Aural Cues	None					
Tactile/ Somatic Cues	None					

B737NG Alerting Issues – Traffic conflict

2. Initiating Condition: Traffic conflict in Next-Gen ATM environment (ground-based sequencing/metering error or datacom error) – Cont.

Expected Pilot Response(s)

- Maneuver the aircraft vertically and/or laterally as directed by ADS-In and CDTI systems.
- If aircraft response is automated, evaluate the validity of the ADS-In and CDTI alerts and monitor the aircraft response.
- If response is manual, execute the response within established next-gen collision avoidance system specifications.

Possible sources of confusion with regard to pilot response(s)

- Tolerances will be so close under NextGen that the ability of pilots to evaluate and respond to traffic conflicts will be limited, and as well, pilot ability to detect and respond to invalid alerts and automated aircraft responses will be limited.
- RA directives may conflict with automated or human ATC directives, which may be a very rare event due to NextGen system reliability (issue: automation dependency). Depending on future display and communications designs for NextGen, pilots may not have complete situational awareness of their aircraft's automated trajectory and its relationship to the traffic conflict.

Issues with regard to multiple concurrent non-normal conditions

- Cascading effects of RA response on NextGen traffic separation and metering.